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ENERGY
COMMISSION

Inventory of Backup Generators in the State of California

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Table of Contents

Section		Page
Preface		vi
Executive Summary		1
Abstract		5
1.0	Introduction	6
2.0	Approach	8
3.0	Database Description	9
4.0	Data Sources	17
4.1.	Air Districts	17
4.2.	Investor Owned Utilities	17
4.3.	Municipal Utilities	17
4.4.	State and Local Government	18
4.5.	Private Industry	18
4.6.	Summary	18
5.0	Quality Assurance / Quality Control	19
6.0	Selected Results	20
6.1.	Geographical Distribution	20
6.2.	Air Districts	21
6.3.	Fuel Type	21
6.4.	Engine Type	21
6.5.	Generating Capacity	21
6.6.	Engine Manufacturer	22
7.0	Impact on Air Emissions	23
Appendix I - Data Sources and Other Organizations Contacted		I-1
Appendix II - Methodology Used to Estimate the Potential Impact of BUG Use on Current Air District NO_x and PM Emissions		II-1

Figure

Figure **Page**

Figure 1. Statewide BUG Distribution 20

List of Tables

Table **Page**

Table 1. Data Source Codes....10
Table 2. Sample Inventory Contents....11
Table 3. Diesel Engine Emissions Factors from the ARB OFFROAD Model....13
Table 4. Dates of Most Recent BUG Inventory Data....16
Table 5. Top Five BUG Manufacturers by Capacity....22
Table 6. NO_x and PM Emissions from Select Electricity Generation Technologies....23
Table 7. Emissions of NO_x and PM by District Compared to the District's Current Daily Total Emissions Inventory....24
Table 8. Emissions of NO_x and PM by district compared to the district's current daily stationary source emissions inventory....25
Table I-1. Air District and Other Data Source Contacts....I-1
Table I-2. Other Organizations Contacted....I-2
Table II-1. Emissions of NO_x and PM by District (tons / hr)....II-2

Preface

The Public Interest Energy Research (PIER) Program supports public interest energy research and development that will help improve the quality of life in California by bringing environmentally safe, affordable, and reliable energy services and products to the marketplace.

The PIER Program, managed by the California Energy Commission (Commission), annually awards up to $62 million to conduct the most promising public interest energy research by partnering with Research, Development, and Demonstration (RD&D) organizations, including individuals, businesses, utilities, and public or private research institutions.

PIER funding efforts are focused on the following six RD&D program areas:

- Buildings End-Use Energy Efficiency
- Industrial/Agricultural/Water End-Use Energy Efficiency
- Renewable Energy
- Environmentally-Preferred Advanced Generation
- Energy-Related Environmental Research
- Strategic Energy Research.

What follows is the final report for the "Backup Generators Assessment" project, Contract Number: 500-98-013, conducted by Arthur D. Little. The report is entitled "Inventory of Backup Generators in the State of California." This project contributes to the Environmentally-Preferred Advanced Generation program.

For more information on the PIER Program, please visit the Commission's Web site at: http://www.energy.ca.gov/pier/reports.html or contact the Commission's Publications Unit at 916-654-5200.

Executive Summary

The present California power crisis is creating an urgent need to look for ways to produce significant amounts of electricity in the near term. Some estimates put the potential short-term power shortage during peak demand periods during the summers of 2001 and 2002 at 5,000 megawatts. A variety of power sources could potentially meet this need, including the current preferred power option of natural gas fired combined cycle power plants. However, the time needed to develop, certify, and construct new power plants typically requires a number of years. Although several power plants are currently under construction and measures have been taken to speed the certification process for proposed plants under review, approved and proposed new power plants cannot fill the need during the next two or three years. One option, existing little used diesel backup generators (BUGs), is under consideration as a possible short-term solution for mitigating the number and extent of shortages.

Previous estimates of the amount of BUG capacity in California have suggested that up to 11,000 BUGs by number totaling as much as 5,000 MW of capacity may exist. The results of an Emission Reduction Technology Assessment for Diesel Backup Generators in California are reported separately. However, confirmation of these estimates has not been possible. For this reason, one main objective of this project was to assemble an inventory database containing detailed information on the number, size, type, location, fuel used, age, and emission characteristics of installed BUGs in the state. Once such a database is assembled, it would be a simple matter to estimate the total number and capacity of BUGs for the state, by region, or any other characteristic documented in the database. As noted below, the initial database documents nearly 4,100 BUGs with capacity greater than 300 kW totaling about 3,200 MW of aggregate capacity.

Approach

The approach used to develop the BUG inventory was to use accessible and comprehensive publicly available sources of information as primary data sources. Because most of the 35 regional Air Quality Management Districts (AQMDs) and Air Pollution Control District s (APCDs) in California require that BUGs be permitted to operate, these regional air districts were targeted as primary data sources. BUG air permit records are generally available for review by the public via a freedom of information (FOI) request. Thus, all 35 districts were contacted and asked to supply BUG air permit information.

Other potential data sources contacted included the three investor-owned utilities in the state, as well as the two largest municipal utilities. Several BUG distributors, select trade organizations, and local government associations were also contacted and available information they had solicited. Data were also received from a few state agencies.

The data obtained from all sources were compiled into a master BUG inventory using Microsoft Excel. Only BUGs with generator capacity of 300 kW or greater were included in the inventory. This spreadsheet database was then imported into ArcView, a geographical information system (GIS) spatial database management system that enables the user to conduct specialized queries and sorts on spatially-linked databases.

Database Description

As of July 6, 2001, the inventory database assembled contains data on 4,097 BUGs with generator capacity of 300 kW or greater, with an estimated aggregate capacity of 3,233 MW. A complete database record for each BUG contains the following information:

- A record number assigned by Arthur D. Little for tracking purposes
- A code corresponding to the source of the information contained in the record; Table 1 summarizes the source codes used
- Facility name
- Air permit application number
- Year of air permit application
- Permit number of air permit issued
- Description of the engine powering the generator as taken from the data source supplying the BUG information
- Primary engine fuel
- Engine manufacturer
- Engine model number
- Generator capacity (kW)
- Engine rating (hp or bhp)
- Facility street address, city, and zip code
- Name of contact person and contact phone number
- Estimated engine emission factor (g / hp-hr) for NO_x and particulate matter (PM)

However, not all BUG records contain complete data.

It is believed that the database represents a comprehensive tabulation of the statewide installed BUG capacity with the exception of coverage for the Bay Area AQMD (BAAQMD). It was not possible to obtain permit record data from BAAQMD because, until recently, emergency standby engines were not required to obtain a district permit. As a consequence, the database only contains information on BUGs in BAAQMD from three sources:

- Silicon Valley Power (the City of Santa Clara)
- PG&E
- A major telecommunication company

The aggregate data from these sources is only partially complete. Overall, it is believed that the database accounts for no more than about 30 to 40 percent of the capacity actually installed in BAAQMD.

The public version of the spreadsheet database has been posted on the Commission's website.

Selected Results

Sorts of that database show that the statewide inventory has the following characteristics:

- ***Air Districts Distribution:*** Five air districts, SCAQMD (2,064 BUGs, 1,713 MW); San Diego County APCD (485 BUGs, 327 MW); BAAQMD (368 BUGs, 325 MW); Sacramento Metropolitan AQMD (291 BUGs, 228 MW), and San Joaquin Valley Unified APCD (314 BUGs, 221 MW) account for 86 percent of the BUGs in the inventory and 87 percent of the generating capacity, despite having very incomplete data on the BAAQMD population.

- ***Fuel Type:*** Approximately 93 percent (3,792 BUGs) of the inventory comprising a similar 93 percent of the generating capacity (3,011 MW) use diesel fuel as the primary engine fuel. Only 101 BUGs with aggregate capacity of 81 MW clearly state a primary fuel other than diesel, distillate oil, or oil. The remainder had no primary fuel specified by the data source.

- ***Engine Type:*** Approximately 85 percent (3,424 BUGs) of the inventory comprising 84 percent of the generating capacity (2,729 MW) are clearly identified as diesel-fueled diesel (compression ignition) engine driven. However, these fractions may be as high as 97 percent (3,976 BUGs) of the inventory and 97 percent (3,124 MW) of the capacity if all BUGs except the 101 stating a primary fuel other than diesel, distillate oil, or oil and the 20 BUGs having 109 MW identified as diesel-fueled turbines are assumed to be diesel-fueled diesel engine driven.

- ***Generating Capacity:*** 2,459 BUGs (60 percent of the total) comprising 1,181 MW of generating capacity (37 percent of the total) are in the 300 to 749 kW size range; the remaining 1,638 (40 percent of the total) comprising 2,052 MW of generation (63 percent of the total) capacity are 750 kW or greater.

- ***Engine Manufacturer:*** About 46 percent of the inventory accounting for over 50 percent of the installed capacity are Caterpillar BUGs. Detroit Diesel and Cummins BUGs comprise about 20 percent of the inventory accounting for about 17 to 19 percent of the capacity. Thus, these three manufacturers have supplied over 86 percent of the inventory comprising 85 percent of the installed capacity.

Potential Impact on Air District Emissions

Diesel engine powered BUGs have substantially greater emissions of NO_x and particulate (PM) than any other power generation technology, when measured on a lb/MWh basis. Thus it is possible that increased BUG utilization as a power source to alleviate near term power shortages could have measurable impacts on regional air quality. To address this question, the emissions associated with operating all diesel BUGs in regional air districts in the state for four hours per day were compared to the districts' current emission inventories.

Results of this comparison show that operating all district diesel BUGs for 4 hr/day would cause NO_x emissions that equal over 2 percent of the district's current total NO_x emissions for 10 of the 13 districts with the largest BUG installed capacity (BAAQMD included). For six of these districts, BUG emissions would total 4 percent or more of the districts' current inventory.

Moreover, for five of these six districts, BUG NO_x emissions could total 40 percent or more of the district's current daily emissions from stationary sources. In fact, for the Sacramento Metropolitan AQMD, diesel BUG emissions for 4 hr / day operation would total 144 percent of the district's current stationary source emissions.

Diesel BUG PM emissions represent less significant fractions of districts' PM inventories. BUG PM emissions equal over 1.5 percent of the districts' total PM emissions inventory for 8 of the 13 districts with the largest BUG installed capacity. The maximum fraction of district stationary source PM inventories is 20 percent, also for the Sacramento Metropolitan AQMD.

Benefits to California

Having assembled and documented this extensive database of BUG capacity in the state, the information now exists to allow informed decisions regarding whether and how best to make use of this generation resource to mitigate the number and extent of any future power shortages in the state. Decision makers now have the data needed to support the development of potential BUG deployment programs to alleviate power shortages, with knowledge of how much capacity can be utilized, where this capacity is located, and what are the air emission characteristics of this capacity. With this knowledge, potential BUG use programs that minimize air quality impacts can be defined, and the acceptability of these impacts judged.

However, it is more likely that this database will be used to improve air emissions inventories from BUGs and provide information that could be critical to authorities in cases of natural or man-made disasters. Also, information from the database will help in developing informed decisions regarding approaches to reducing emissions from diesel engines and associated air quality impacts.

Abstract

One option under consideration as a possible short-term solution to mitigating the number or extent of power shortages forecast during the present California power crisis is making use of the backup generator (BUG) capacity installed in the state. However, the degree to which this potential resource can be utilized requires knowledge of its size and characteristics. To address this need, one main objective of the project was to assemble an inventory database containing detailed information on the number, size, type, location, fuel used, age, and emission characteristics of installed BUGs in the state. This database was assembled largely from BUG air permit information obtained from the regional AQMDs and APCDs in the state, supplemented by data received from a few state agencies, a public and private utility, and one private company.

The data obtained from these sources were assembled into a master BUG inventory using Microsoft Excel. As of July 6, 2001, this inventory contained data on 4,097 BUGs with generator capacity of 300 kW or greater, with an estimated aggregate capacity of 3,233 MW. The public version of this database has been posted on the California Energy Commission website.

1.0 Introduction

The present California power crisis is creating an urgent need to look for ways to produce significant amounts of electricity in the near term. Some estimates put the potential short-term power shortage during peak demand periods during the summers of 2001 and 2002 at 5,000 megawatts. A variety of power sources could potentially meet this need, including the current preferred power option of natural gas fired combined cycle power plants. However, the time needed to develop, certify, and construct new power plants typically requires a number of years. Although several power plants are currently under construction and measures have been taken to speed the certification process for proposed plants under review, approved and proposed new power plants cannot fill the need during the next two or three years. One option, existing little used diesel backup generators (BUGs), is under consideration as a possible short-term solution for mitigating the number and extent of shortages.

Estimates of the amount of BUG capacity in California have suggested that up to 11,000 BUGs by number totaling as much as 5,000 MW of capacity may exist. However, confirmation of these estimates has not been possible. For this reason, one main objective of this project was to assemble an inventory database containing detailed information on the number, size, type, location, fuel used, age, and emission characteristics of installed BUGs in the state. Once such a database is assembled, it would be a simple matter to estimate the total number and capacity of BUGs for the state, by region, or any other characteristic documented in the database.

Based on the previous BUG capacity estimates, it was clear that the majority of back-up generators in use employ diesel engines using diesel fuel. Further, most of these engines have no modern emission controls and can be the source of significant amounts of particulate matter (PM) and nitrogen oxide (NO_x) air emissions. Therefore, a second major objective of this project was to assess means to mitigate the air emissions associated with increased BUG operation. Specifically, two approaches were evaluated: alternate, cleaner burning fuels and emissions control technology hardware.

Results of the project are summarized in two separate reports. This report covers the BUG inventory database. Results of the assessment of ways to mitigate air emissions impacts from diesel-fueled BUGs are reported separately.

This report is organized as follows:

- Section 2: A description of the approach used to develop the BUG inventory.
- Section 3: A description of the inventory database assembled.
- Section 4: A discussion of the data sources used to obtain the BUG information included in the inventory
- Section 5: A discussion of the quality assurance / quality control (QA / QC) employed to validate the data in the BUG inventory.
- Section 6: A discussion of select results taken from the BUG inventory

- Section 7: discussion of the potential impact of diesel BUG operation on current air district NO_x and PM emissions

- Appendix I: provides data sources and organizations contacted

- Appendix II: describes the methodology used to estimate the potential impact of BUG use on current air districts NO_x and PM emissions

The master inventory as of July 6, 2001, in the form of an Excel spreadsheet has been submitted to the Commission. An ArcView geographic information system (GIS) file containing the same inventory information has been submitted on a compact disk (CD). The public version of the spreadsheet file has been posted on the Commission's website.

2.0 Approach

The approach used to develop the BUG inventory was to use accessible and comprehensive publicly available sources of information as primary data sources. Because most of the 35 regional Air Quality Management Districts (AQMDs) and Air Pollution Control District's (APCDs) in California require that BUGs be permitted to operate, these regional air districts were targeted as primary data sources. BUG air permit records are generally available for review by the public via a freedom of information (FOI) request. Thus, all 35 districts were contacted and asked to supply BUG air permit information.

Other potential data sources contacted included the three major investor-owned utilities (IOUs): Southern California Edison (SCE), Pacific Gas & Electric (PG&E), and San Diego Gas and Electric (SDG&E), as well as the two largest municipal utilities, the Los Angeles Department of Water and Power (LADWP) and the Sacramento Municipal Utility District (SMUD). Several BUG distributors, select trade organizations, local government associations, and the California Independent System Operator (CAISO) were also contacted and asked for information they had available on installed BUGs. Potential data sources contacted are listed in Appendix I.

A discussion of the sources that supplied data to the inventory assembly effort is given in Section 4. The data obtained from these sources were compiled into a master BUG inventory using Microsoft Excel. Only BUGs with generator capacity of 300 kW or greater were included in the inventory. This spreadsheet database was then imported into ArcView, a geographical information system (GIS) spatial database management system developed by ESRI. ArcView enables the user to conduct specialized queries and sorts on spatially-linked databases.

3.0 Database Description

As of July 6, 2001, the inventory database assembled contains data on 4,097 BUGs with generator capacity of 300 kW or greater, with an estimated aggregate capacity of 3,233 MW. A complete database record for each BUG contains the following information:

- A record number assigned by Arthur D. Little for tracking purposes
- A code corresponding to the source of the information contained in the record; Table 1 summarizes the source codes used
- Facility name
- Air permit application number
- Year of air permit application
- Permit number of air permit issued
- Description of the engine powering the generator as taken from the data source supplying the BUG information
- Primary engine fuel
- Engine manufacturer
- Engine model number
- Generator capacity (kW)
- Engine rating (hp or bhp)
- Facility street address, city, and zip code
- Name of contact person and contact phone number
- Estimated engine emission factor (g / hp-hr) for NO_x and particulate matter (PM)

Table 2 gives a sample of the information included in the public inventory for 14 BUGs. The public version of the complete inventory has been placed on the Commission's website.

Not all the fields have completed information for all the BUGs in the inventory. For example, the engine description field has information to various degrees of detail depending on the completeness of data obtained from the source. In many cases no information was obtained. In addition, either generator capacity or engine horsepower rating was generally available, but not both. In instances in which only the engine rating was available from the data source, the associated generator capacity was estimated using a conversion factor of 0.67 kW / hp. In the database, the generator capacity or engine horsepower rating (hp or bhp) supplied by the data source is entered in one of the three columns labeled "Stated Generator Capacity (kW)," "Stated Engine Rating (hp)," or "Stated Engine Rating (bhp)." The column labeled "Generator Capacity" contains the capacity assumed for each individual BUG. The entry is the stated generator capacity when given, or 0.67 multiplied by the stated engine horsepower rating when only the engine rating was given.

Table 1. Data Source Codes

Source Code	Corresponding Data Source
AMA	Amador County APCD
AV	Antelope Valley APCD
BTT	Butte County AQMD
CLS	Colusa County APCD
CSC	Silicon Valley Power (City of Santa Clara)
DOC	California Department of Corrections
DWP	Los Angeles Department of Water and Power
EDC	El Dorado County APCD
FRV	Feather River AQMD
GB	Great Basin Unified APCD
GLN	Glenn County APCD
IMP	Imperial County APCD
KRN	Kern County APCD
LKE	Lake County AQMD
MAR	Mariposa County APCD
MB	Monterey Bay Unified APCD
MEN	Mendocino County AQMD
MHV	Mohave Desert AQMD
NCT	North Coast Unified AQMD
OEA	Office of Energy Assessments of the California Department of General Services
PGE	Pacific Gas & Electric
PLC	Placer County APCD
SAC	Sacramento Metropolitan AQMD
SB	Santa Barbara County APCD
SC	South Coast AQMD
SD	San Diego County APCD
SHA	Shasta County AQMD
SJV	San Joaquin Valley Unified APCD
SLO	San Luis Obispo County APCD
THM	Tehama County APCD
VEN	Ventura County APCD
VRZ	Major Telecommunications Company
YS	Yolo Solano AQMD

Table 2. Sample Inventory Contents

Record Number	Data Source	Facility Name	Permit Application Number	Permit Application Year	Permit Number	Engine Description	Primary Fuel	Manufacturer	Model
0001	SC	1875/1925 CENTURY PARK EAST CO	296382	1994	D85615	ICE, CATERPILLAR, DIESEL, EMR, MODEL 3412, SN 3857846, TURBOCHARGED, AFTERCOOLED, 12 CYL, 755 BHP	Diesel	Caterpillar	3412
0002	SC	20TH CENTURY FOX FILM CORP	330886	1997	F8672	ICE, CUMMINS, DIESEL, EMR, MODEL KTTA50-G2, SN H960614528, TURBOCHARGED, AFTERCOOLED, 16 CYL, 2220 BHP, EMR	Diesel	Cummins	KTTA50-G2
0003	SC	20TH CENTURY FOX FILM CORP	330887	1997	F8676	ICE, CUMMINS, DIESEL, EMR, MODEL KTTA50-G2, SN H960614527, TURBOCHARGED, AFTERCOOLED, 16 CYL, 2220 BHP, EMR	Diesel	Cummins	KTTA50-G2
0004	SC	20TH CENTURY FOX FILM CORP	330888	1997	F8683	ICE, CUMMINS, DIESEL, EMR, MODEL QST30-G2, TURBOCHARGED, AFTERCOOLED, 12 CYL, 800 KW, EMR	Diesel	Cummins	QST30-G2
0005	SC	20TH CENTURY INSURANCE CO	361864	1999	F23017	ICE, CUMMINS, DIESEL, EMR, MODEL KTA50-G9, EMR TURBOCHARGED, AFTERCOOLED, 16 CYL, 1500 KW	Diesel	Cummins	KTA50-G9
0006	SC	3 HUTTON CENTRE LP, CUSHMAN & WAKERFIELD	286110	1993	D77795	ICE, CUMMINS, DIESEL, EMR, MODEL VTA 28 G1, SN 37108962, EMR TURBOCHARGED, AFTERCOOLED, 12 CYL, 760 BHP	Diesel	Cummins	VTA28-G1
0007	SC	360 NETWORKS (USA) INC	377563	2000	F35656	ICE, CATERPILLAR, DIESEL, 12 CYL, TURBOCHARGED, AFTERCOOLED, MODEL 3512B DITA, SN 8RM00626, 1500 KW, EMR	Diesel	Caterpillar	3512B DITA
0008	SC	360 NETWORKS (USA) INC	377564	2000	F35657	ICE, CATERPILLAR, DIESEL, 12 CYL, TURBOCHARGED, AFTERCOOLED, MODEL 3512B DITA, SN 8RM00627, 1500 KW, EMR	Diesel	Caterpillar	3512B DITA
0009	SC	360 NETWORKS (USA) INC	377566	2000	F35661	ICE, CATERPILLAR, DIESEL, 12 CYL, TURBOCHARGED, AFTERCOOLED, MODEL 3512B DITA, SN 8RM00628, 1500 KW, EMR	Diesel	Caterpillar	3512B DITA
0010	SC	450 NORTH BRAND LLC	363450	1999	F23702	ICE, DETROIT DIESEL, 12 CYL, TURBOCHARGED, AFTERCOOLED, MODEL 12V-92TA, SN 12VF013933, 830 BHP, EMR	Diesel	Detroit Diesel	12V-92TA
0011	SC	4MC-BURBANK, INC.	298769	N/A	D86895	ICE, CUMMINS, DIESEL, EMR, MODEL KTA-38-G1. SN 33116663, TURBOCHARGED, AFTERCOOLED, 6 CYL, 1135 BHP	Diesel	Cummins	KTA38-G1
0012	SC	4MC-BURBANK, INC.	357595	1999	F21411	ICE, CATERPILLAR, 12 CYL, TURBOCHARGED, AFTERCOOLED, MODEL 3512 DITA, 1250 KW, DIESEL, EMR	Diesel	Caterpillar	3512 DITA
0013	SC	550 NORTH BRAND OWNER'S CORP	286105	1993	D77793	ICE, CATERPILLAR, 12 CYL, TURBOCHARGED, AFTERCOOLED, MODEL 3412, SN 81205336, 558 BHP, DIESEL, EMR	Diesel	Caterpillar	3412

able 2. Sample Inventory Contents (continued)

Record Number	Data Source	Facility Name	Generator Capacity (kW)	Stated Generator Capacity (kW)	Stated Engine Rating (hp)	Stated Engine Rating (bhp)	Facility Address	City	Zip Code	NOx Emission Factor (g/bhp-hr)	PM Emission Factor (g/bhp-hr)
0001	SC	1875/1925 CENTURY PARK EAST CO	503			755	1875 CENTURY PARK E	LOS ANGELES	90067	8.17	0.38
0002	SC	20TH CENTURY FOX FILM CORP	1480			2220	10201 W PICO BLVD BLDG 99	LOS ANGELES	90064-2651	8.17	0.38
0003	SC	20TH CENTURY FOX FILM CORP	1480			2220	10201 W PICO BLVD BLDG 99	LOS ANGELES	90064-2651	8.17	0.38
0004	SC	20TH CENTURY FOX FILM CORP	800	800			10201 W PICO BLVD BLDG 99	LOS ANGELES	90064-2651	8.17	0.38
0005	SC	20TH CENTURY INSURANCE CO	1500	1500			6301 OWENSMOUTH AVE	WOODLAND HILLS	91367-2286	8.17	0.38
0006	SC	3 HUTTON CENTRE LP, CUSHMAN & WAKERFIELD	507			760	3 HUTTON CENTRE DR	SANTA ANA	92707	8.17	0.38
0007	SC	360 NETWORKS (USA) INC	1500	1500			600 W 7 TH ST	LOS ANGELES	90017	6.9	0.4
0008	SC	360 NETWORKS (USA) INC	1500	1500			600 W 7 TH ST	LOS ANGELES	90017	6.9	0.4
0009	SC	360 NETWORKS (USA) INC	1500	1500			600 W 7 TH ST	LOS ANGELES	90017	6.9	0.4
0010	SC	450 NORTH BRAND LLC	553			830	450 N BRAND BLVD	GLENDALE	91209	8.17	0.38
0011	SC	4MC-BURBANK, INC.	757			1135	2901 W ALAMEDA AVE	BURBANK	91505		
0012	SC	4MC-BURBANK, INC.	1250	1250			2901 W ALAMEDA AVE	BURBANK	91505	8.17	0.38
0013	SC	550 NORTH BRAND OWNER'S CORP	372			558	550 N BRAND BLVD	GLENDALE	91203	8.17	0.38

The facility name and address fields in a small number of the records are blank in the public version of the inventory. These were omitted because the information provided was considered to be confidential. In addition, the contact information has been omitted from the public version of the inventory.

Specific discussion of the estimated NO_x and PM emission factors included in the data base is warranted. The California Air Resources Board (ARB) has defined emission factors for diesel engines for use in estimating the contribution to the statewide NO_x and PM emissions of off road mobile sources. These emission factors, included in the ARB OFFROAD emissions inventory model, are average values for diesel engines in various model year and size categories based on manufacturer data and emission test results. They are not engine make or model specific. However, they represent the best documented and most comprehensive set of emission factors and can be considered representative of the average engine population. Table 3 summarizes these emission factors.

Table 3. Diesel Engine Emissions Factors from the ARB OFFROAD Model

Engine Model Year	Emission Factor, g/hp-hr			
	NO_x		PM	
	Engines ≤750 hp	Engines >750 hp	Engines ≤750 hp	Engines >750 hp
1983 and earlier	12	12	0.53	0.53
1984 through 1987	11	11	0.53	0.53
1988 through 1995	8.17	8.17	0.38	0.38
1986 through 1999	6.90	8.17	0.40	0.38
2000 to present	6.90	6.90	0.40	0.40

To estimate the emission factor for an individual diesel-fueled BUG requires knowledge of the engine model year and rating or capacity. While engine rating or generator capacity was known for all BUGs in the database, engine model year was rarely given by the data source supplying information. As a consequence, it was decided to use the year the BUG's air permit application was submitted as an approximation to the engine model year. However, even this approach had limitations. Specifically, permit application date data were only available from the following data sources:

- South Coast AQMD
- Sacramento Metropolitan AQMD
- Monterey Bay Unified APCD
- Yolo-Solano AQMD
- El Dorado County APCD
- Feather River AQMD

- Imperial County APCD
- Butte County APCD
- Shasta County AQMD
- Lake County AQMD
- Glenn County APCD
- Mariposa County APCD
- Colusa County APCD
- PG&E (many though not all BUGs)

The emission factor fields for BUGs in the inventory from these sources have entries corresponding to the BUG capacity and permit application year taken from Table 3. No entries are included in the inventory for those BUGS for which the permit application year was not known.

It is believed that the database represents a comprehensive tabulation of the statewide installed BUG capacity with a few notable exceptions. The most notable is the inventory coverage for the Bay Area AQMD (BAAQMD). It was not possible to obtain permit record data from BAAQMD because, until recently, emergency standby engines were not required to obtain a district permit. As a consequence, the database only contains information on BUGs in BAAQMD from three sources:

- Silicon Valley Power (the City of Santa Clara)
- PG&E
- A major telecommunication company

The Silicon Valley Power data provides a relatively complete picture of the installed capacity in the City of Santa Clara, but only facility names, addresses, and BUG capacity were supplied. The data supplied by the telecommunications company was relatively complete, but only a few BUGs were located in BAAQMD. Data from PG&E were acknowledged to be only partially complete. Overall, it is believed that the database accounts for no more than about 30 to 40 percent of the capacity actually installed in BAAQMD. This estimate is based on a population weighted extrapolation from the SCAQMD inventory.

The second exception concerns the completeness of the data for the South Coast AQMD (SCAQMD). As of July 6, 2001, the database contained information from SCAQMD on 2,034 BUGs with aggregate capacity of 1,694 MW. These data were transcribed from a permit image file database at SCAQMD. Permit images selected to supply information to the database were identified by sorting a searchable corporate database maintained at the district for equipment categories of interest, specifically backup electric generators with engines greater than 500 hp. SCAQMD uses 500 hp (335 kW) as the break point between large engine-driven equipment and smaller equipment in their permit records. As a consequence of this break point definition, the SCAQMD portion of the inventory does not include BUGs with nominal generating capacities of between 300 and 335 kW.

Finally, data obtained from the Ventura County APCD and the Santa Barbara County APCD were acknowledged to be incomplete by the district personnel that supplied information to the study.

In general, the inventory database is current through the date of data submitted by the data source to Arthur D. Little, usually March or April 2001. The actual dates are given in Table 4. Data from the California Department of Corrections (DOC) were stated complete through May 2000, and from the San Diego County APCD through permit applications received as of November 2000. The 14 air district data sources having identified installed capacity of 15 MW or greater are being requested to provide routine updates on new capacity permitted. These will be added to the inventory database periodically.

Table 4. Dates of Most Recent BUG Inventory Data

Source	Number of BUGs	Total MW	Database Current Through:
Air Districts			
South Coast AQMD	2,034	1,694	April 2001
San Diego County APCD	483	324	November 2000
Sacramento Metro AQMD	286	223	April 2001
San Joaquin Valley Unified APCD	313	219	March 2001
Monterey Bay Unified APCD	112	76	March 2001
Yolo/Solano AQMD	59	47	April 2001
Ventura County APCD	46	40	Incomplete data
Mojave Desert AQMD	62	35	March 2001
Placer County APCD	26	34	April 2001
Antelope Valley APCD	34	20	March 2001
San Luis Obispo County APCD	15	17	March 2001
El Dorado County APCD	23	16	April 2001
Kern County APCD	36	15	April 2001
Feather River AQMD	21	15	April 2001
Imperial County APCD	6	10	April 2001
Butte County AQMD	13	9	April 2001
Great Basin Unified APCD	11	8	March 2001
Santa Barbara County APCD	13	8	March 2001, incomplete recordkeeping prior to 2001
Amador County APCD	8	7	April 2001
Shasta County AQMD	9	6	April 2001
Lake County AQMD	8	4	April 2001
Mendocino County AQMD	3	2	April 2001
Glenn County APCD	3	2	April 2001
Mariposa County APCD	3	1	April 2001
Tehama County APCD	3	1	April 2001
North Coast Unified AQMD	1	1	April 2001
Colusa County APCD	2	1	April 2001
Other Sources			
Pacific Gas & Electric	317	279	Not known
Silicon Valley Power	42	36	April 2001
Los Angeles Dept. of Water and Power	7	6	April 2001
Office of Energy Assessments-California Department of General Services	7	8	March 2001
California Department of Corrections	30	37	May 2000
Major Telecommunications Company	61	34	April 2001
Totals	**4,097**	**3,233**	

4.0 Data Sources

Of the potential data sources identified in Section 2 that were contacted, those that provided the most comprehensive information on the installed BUG population were the air districts. Information from the air districts largely came from permit files. Data on some BUGs were also obtained from two state agencies, the northern California investor-owned utility, a municipal utility, and one private company. A summary of the contacts made and the data received is given in the following subsections.

4.1. Air Districts

Initial efforts focused on gathering information on installed BUGs from the permit records of the 35 APCDs and AQMDs in the state. Of these, 27 acknowledged having data on permitted BUGs and supplied these data. The BAAQMD had no data to supply and another seven rural air districts stated that no BUGs with capacity greater than 300 kW existed or that no records on BUG sources were kept by the district.

Of the APCDs and AQMDs supplying data, many had already compiled electronic spreadsheet files containing air permit information on BUGs in the districts. The districts having these electronic inventories provided these. A few districts compiled the BUG information in word processing files; other districts did not have electronic files and either sent paper copies of permits or allowed Arthur D. Little staff to copy files in their offices.

4.2. Investor Owned Utilities

All three IOUs in California were contacted in an attempt to get information on BUGs that could either corroborate BUG data obtained from air district sources or, in the case of the Bay Area, serve as a primary data source, as no permit data were available from BAAQMD. However, all three IOUs were found to be bound by a CPUC rule that prohibits them from providing specific information on their customers. SCE and SDG&E indicated that they had not compiled comprehensive inventories on customers with BUGs. PG&E acknowledged they had compiled an inventory of customers with BUGs, but could not make it generally available due to the CPUC rule.

Because the BAAQMD did not have any information on BUGs in the district, the confidential PG&E BUG data became viewed as the only available source of data for most of the Bay Area. Accordingly, the CPUC was asked to assist the Commission in obtaining the information from PG&E. In response to this request, CPUC issued an order to PG&E directing the release of the confidential data. Data received from PG&E are included in the inventory database, but, as noted in Section 3, these data provide a very incomplete picture of the installed capacity in BAAQMD.

4.3. Municipal Utilities

The largest two municipal utilities in California, SMUD and LADWP, were contacted to request any information they may have had on BUGs in their service territories. LADWP provided information on a few BUGs they were aware of. The SMUD information on BUGs in their territory was the same as that obtained from the Sacramento Metropolitan AQMD. Members of the California Municipal Utilities Association (CMUA) were also contacted. With one exception,

the member utilities that responded did not have BUGs larger than 300 kW capacity. The notable exception was the City of Santa Clara's municipal utility, Silicon Valley Power, who provided information on BUGs in that city.

4.4. State and Local Government

Several state and local government agencies were contacted for BUG information. The majority of the government agencies contacted had no information. However, two state agencies had developed BUG inventories, the California Department of General Services, Office of Energy Assessments (OEA) and the California DOC. Both of these agencies provided their inventory data for use in this project.

4.5. Private Industry

The Caterpillar and Cummins engine distributors for Northern California were contacted to request any sales data they might make available to supplement the inventory, especially in BAAQMD. Both declined to supply what they consider to be customer confidential information.

Finally, as noted in Section 5, the top 20 BUG owners (MW capacity) based on all previously assembled data were contacted as part of the database quality assurance / quality control (QA / QC) effort. During this effort, one owner, a major telecommunications company, voluntarily provided their in-house BUG database for use in this project.

4.6. Summary

All the air districts contacted, as well as the other data sources that provided detailed information to this inventory assembly effort are listed in Table I-1 in Appendix I. This table also notes the form of the information received. The table confirms that the local air districts were the most common data source.

5.0 Quality Assurance/Quality Control

A QA / QC process was performed on subsets of the data received from the primary data sources listed in Table 1. For the purposes of this project, a BUG record was considered validated if the information contained for a BUG record in the master database was confirmed by information received from a second source. The second source was either (1) a second database in which a BUG appeared or (2) direct contact with a BUG owner.

Second sources supplying database information that confirmed information received from the primary data source included

- LADWP
- The Office of Energy Assessment of the California Department of General Services
- The California Department of Corrections (DOC)
- A major telecommunications company in the state

Comparing this second source database information to data obtained from a primary source showed, for example, that 83 out of the 144 BUGs listed in the telecommunications company's database also appeared in one of the air district databases. Similarly, 59 out of the 89 BUGs listed in the DOC's database also appeared in one of the air district databases.

The second QA / QC process involved directly contacting with BUG owners. Two subsets of the BUG population were contacted: owners of BUGs with a capacity (per unit) equal to or greater than 2 MW and the twenty largest BUG owners based on total statewide MW capacity. Telephone interviews were conducted to (1) validate the basic inventory data (i.e., make, model, year, fuel type, etc.) and (2) to ask more specific questions about BUG use at a given facility.

All data items for each BUG obtained from second sources (generally all the database record items discussed in Section 3) were compared to corresponding information in the master inventory database. Discrepancies were noted and corrections made as appropriate.

A total of 309 BUG records (or approximately 8 percent of the total database) representing 318 MW of capacity (10 percent of the total in the inventory) were validated as part of the QA / QC process.

6.0 Selected Results

Having once developed the database in spreadsheet format, it becomes a relatively simple matter to do "sorts" of the data to determine various characteristics of the BUGs population. Several sorts of common interest to many interested in BUGs are presented below.

6.1. Geographical Distribution

As noted in Section 2, the Excel spreadsheet inventory database was imported into ArcView GIS spatial database management system. Figure 1 shows the distribution of the 4,097 BUGs in the inventory throughout the state in two size ranges, 300 to 749 kW and 750 kW and larger. As can be seen, the vast majority of BUGs are located near metropolitan areas, independent of size. It should be recalled that the database for the Bay Area is incomplete.

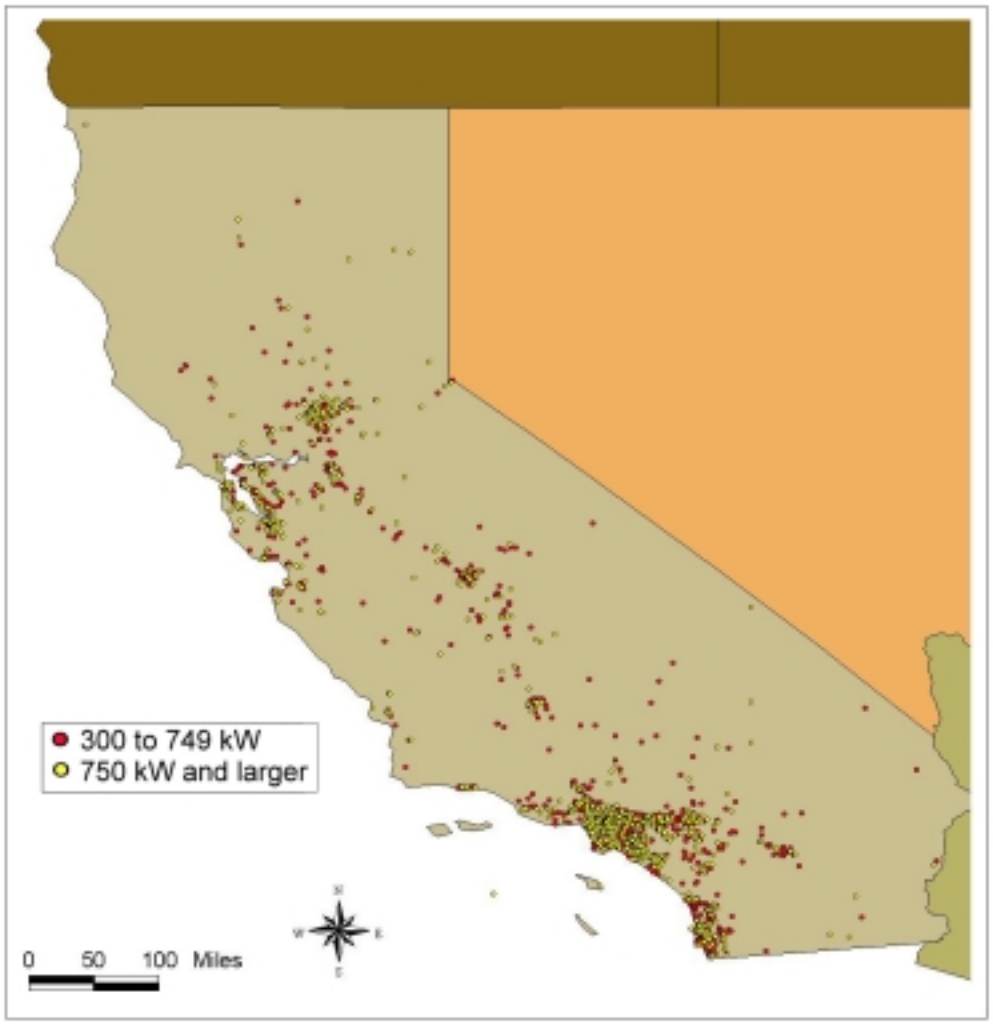

Figure 1. Statewide BUG Distribution

6.2. Air Districts

Five air districts, SCAQMD (2,064 BUGs, 1,713 MW); San Diego County APCD (485 BUGs, 327 MW); BAAQMD (368 BUGs, 325 MW); Sacramento Metropolitan AQMD (291 BUGs, 228 MW), and San Joaquin Valley Unified APCD (314 BUGs, 221 MW) account for 86 percent of the BUGs in the inventory and 87 percent of the generating capacity, despite having very incomplete data on the BAAQMD population (the numbers and MW capacities above may differ from the air district entries in Table 4 because BUGs identified by other sources noted in the table have been added to those identified by the air districts). Once again, this illustrates that BUGs are located primarily in urban areas.

6.3. Fuel Type

Approximately 93 percent (3,792 BUGs) of the inventory comprising a similar 93 percent of the generating capacity (3,011 MW) use diesel fuel as the primary engine fuel. Only 101 BUGs with aggregate capacity of 81 MW clearly state a primary fuel other than diesel, distillate oil, or oil. The remainder had no primary fuel specified by the data source.

6.4. Engine Type

Approximately 85 percent (3,424 BUGs) of the inventory comprising 84 percent of the generating capacity (2,729 MW) are clearly identified as diesel-fueled diesel (compression ignition) engine driven. However, these fractions may be as high as 97 percent (3,976 BUGs) of the inventory and 97 percent (3,124 MW) of the capacity if all BUGs except the 101 stating a primary fuel other than diesel, distillate oil, or oil and the 20 BUGs having 109 MW identified as diesel-fueled turbines are assumed to be diesel-fueled diesel engine driven.

6.5. Generating Capacity

2,459 BUGs (60 percent of the total) comprising 1,181 MW of generating capacity (37 percent of the total) are in the 300 to 749 kW size range; the remaining 1,638 (40 percent of the total) comprising 2,052 MW of generation (63 percent of the total) capacity are 750 kW or greater.

6.6. Engine Manufacturer

About 46 percent of the inventory accounting for over 50 percent of the installed capacity are Caterpillar BUGs. Detroit Diesel and Cummins BUGs comprise about 20 percent of the inventory accounting for about 17 to 19 percent of the capacity. Thus, these three manufacturers have supplied over 86 percent of the inventory comprising 85 percent of the installed capacity. Table 5 lists the top five manufacturers by installed capacity. These five account for 89 percent of the population in the inventory and 89 percent of the capacity. No other manufacturer comprises more than one percent of either the population or the installed capacity.

Table 5. Top Five BUG Manufacturers by Capacity

Manufacturer	Number of BUGs in Inventory	Fraction of Population %	Capacity in Inventory MW	Fraction of Capacity %
Caterpillar	1,882	45.9	1,629	50.4
Detroit Diesel	858	20.9	609	18.8
Cummins	804	19.6	535	16.6
Waukesha	74	1.8	56	1.7
General Motors	33	0.8	55	1.7
Top 5 Total	3,651	89.0	2,884	89.2

7.0 Impact on Air Emissions

Diesel engine powered BUGs have substantially greater emissions of two regulated pollutants, NO_x and particulate (PM) than any other power generation technology, when measured on a lb / MWh basis. For example, Table 6 gives the California Air Resources Board (ARB) estimates of the emission rates of these two pollutants on this basis for several power generation technologies. As indicated in the table, existing diesel BUG NO_x emissions are a factor of 25 to 60 times greater than from current new gas-fired simple cycle gas turbine peaking units, a factor of 50 to 60 times greater than from the existing California mix of gas-fired power plants, and a factor of 500 to 600 times greater than from new gas-fired combined cycle power plants with selective catalytic reduction (SCR). Similarly, existing diesel-fueled diesel BUG PM emissions are 15 to 100 times greater than from gas-fired power generation processes. Moreover, ARB has determined that diesel PM is a toxic air contaminant because of its carcinogenic characteristics.

Table 6. NO_x and PM Emissions from Select Electricity Generation Technologies

Technology	Emission Factor[a] lb/MWh
NOx Emissions	
Existing diesel-fueled diesel engine BUGs	25 to 30
New gas-fired simple cycle gas turbine without SCR	0.5 to 1
Typical mix of California gas-fired power plants	0.5
New gas-fired combined cycle power plant with SCR	0.05
PM Emissions	
Existing diesel-fueled diesel engine BUGs	1 to 3
Gas-fired power generation	0.03 to 0.07

[a]Letter from Michael P. Kenny, Executive Officer, ARB to Air Pollution Control Officers, February 21, 2001.

Given their substantially greater emission rates, it is possible that increased diesel BUG utilization as a power source to mitigate the number and extent of power outages in the state could have measurable impacts on regional air quality. To address this question, the emissions associated with operating all diesel BUGs for four hours per day in each of the air districts (except BAAQMD and the seven rural districts with no BUGs or no BUG records) was compared to the district's current total and stationary source NO_x and PM emission inventories. A number of assumptions are needed to make these comparisons; the methodology for estimating the emissions associated with an air district inventory of diesel BUGs is discussed in Appendix II.

Table 7 presents the potential impact of BUGs operation on daily total NO_x and PM emissions. In this table, the 13 districts with diesel BUG inventory capacity greater than 15 MW are listed individually; the remaining 14 districts are combined together in an other district total. The data in Table 7 show that operating all diesel BUGs for 4 hr/day would cause NO_x emissions that equal over two percent of a district's current total NO_x emissions. This occurs for 10 of the 13 districts noted in the table. For six of the districts, BUG emissions would total 4 percent or more of the district's current inventory. This impact is not insignificant. Similarly, BUG PM emissions equal over 1.5 percent of the district's current total PM emissions inventory for 8 of the 13 districts listed in the table.

Table 7. Emissions of NO_x and PM by District Compared to the District's Current Daily Total Emissions Inventory

Air District	NO_x (tons/day)			PM (tons/day)		
	BUG Emissions, 4 hr/day Operation	District Total Inventory	Percentage of Inventory	BUG Emissions, 4 hr/day Operation	District Total Inventory[a]	Percentage of Inventory
South Coast	63.7	1,237.3	5.1%	3.16	75.3	4.2%
San Diego	12.7	236.4	5.4%	0.62	20.0	3.1%
Sacramento Metro	8.5	112.0	7.6%	0.42	6.0	7.0%
San Joaquin Valley Unified	8.4	598.0	1.4%	0.41	96.0	0.4%
Monterey Bay Unified	3.2	48.7	6.6%	0.15	9.0	1.7%
Yolo/Solano	1.8	73.0	2.5%	0.09	9.7	0.9%
Ventura	1.6	75.7	2.1%	0.08	5.0	1.6%
Placer	1.4	29.6	4.7%	0.07	4.1	1.7%
Mojave Desert	1.3	154.0	0.8%	0.07	21.0	0.3%
Antelope Valley	0.7	31.7	2.2%	0.04	2.0	2.0%
San Luis Obispo	0.7	31.1	2.3%	0.03	5.6	0.5%
El Dorado	0.6	15.1	4.0%	0.03	1.9	1.6%
Feather River	0.6	24.0	2.5%	0.03	6.7	0.4%
Other Districts	2.6	293.9	0.9%	0.13	67.6	0.2%

[a]For PM, daily inventory includes all sources except for natural and anthropogenic dust producing processes.

Perhaps a better measure of the potential impact of increased diesel BUG operation is to make the comparison to district stationary source emissions inventories. Table 8 provides this comparison. The data in this table show that operating all diesel BUGs for 4 hr / day could cause NO_x emissions that equal more significant fractions of the district's current daily emissions from all other stationary sources. For six of the 13 individually listed districts, BUG emissions could represent 40 percent or more of the districts' current stationary source emissions. In fact, for the Sacramento Metropolitan AQMD, diesel BUG emissions for 4 hr / day operation would total 144 percent of the district's current stationary source emissions.

Table 8. Emissions of NO_x and PM by district compared to the district's current daily stationary source emissions inventory

Air District	NO_x (tons/day)			PM (tons/day)		
	BUG Emissions, 4 hr/day Operation	Stationary Source Inventory[a]	Percentage of Inventory	BUG Emissions, 4 hr/day Operation	Stationary Source Inventory[a]	Percentage of Inventory
South Coast	63.7	149.6	43%	3.16	32.63	10%
San Diego	12.7	21.9	58%	0.62	8.68	7.1%
Sacramento Metro	8.5	5.9	144%	0.42	2.15	20%
San Joaquin Valley Unified	8.4	197.2	4.3%	0.41	79.6	0.5%
Monterey Bay Unified	3.2	16.9	19%	0.15	7.62	2.0%
Yolo/Solano	1.8	12.9	14%	0.09	5.38	1.7%
Ventura	1.6	17.0	9.4%	0.08	2.53	3.2%
Placer	1.4	2.4	57%	0.07	3.04	2.3%
Mojave Desert	1.3	102.1	1.3%	0.07	19.2	0.4%
Antelope Valley	0.7	1.4	53%	0.04	0.9	4.4%
San Luis Obispo	0.7	4.5	15%	0.03	4.37	0.7%
El Dorado	0.6	1.3	46%	0.03	1.21	2.5%
Feather River	0.6	3.9	15%	0.03	5.78	0.5%
Other Districts	2.6	72.0	3.6%	0.13	54.25	0.2%

[a]For NO_x, daily inventory includes all stationary sources. For PM, daily inventory includes stationary sources except for natural and anthropogenic dust producing processes.

Diesel BUG PM emissions represent less significant fractions of districts' stationary source PM. The maximum fraction, at 20 percent, is also for the Sacramento Metropolitan AQMD. However, specific locations could be significantly affected by diesel BUG operation, especially considering the carcinogenic nature of diesel PM.

The potential significance of the air quality effects of increased diesel BUG operation to address short-term power strategy points to the need to evaluate means of mitigating their emissions. This is the subject of the companion report prepared in this project.

Appendix I - Data Sources and Other Organizations Contacted

All the air districts contacted, as well as the other data sources that provided detailed information to this inventory assembly effort are listed in Table I-1. This table notes the contact individual, and the form of the information received. Other organizations contacted that were unable to supply detailed BUG information are listed in Table I-2.

Table I-1. Air District and Other Data Source Contacts

Sources	Phone	Fax	Data Type
Air Districts			
Amador County APCD	(209) 223-6406	(209) 223-6260	MS Excel
Antelope Valley APCD	(661) 723-8070	(661) 723-3450	MS Excel
Bay Area AQMD	(415) 771-6000	(415) 928-8560	No BUG Records
Butte County AQMD	(530) 891-2882	(530) 891-2878	MS Access
Calaveras County APCD	(209) 754-6504	(209) 754-6521	No BUG Records
Colusa County APCD	(530) 458-0590	(530) 458-5000	Fax Summary
El Dorado County APCD	(530) 621-6662	(530) 642-1531	Paper Permits
Feather River AQMD	(530) 634-7659	(530) 634-7660	MS Excel
Glenn County APCD	(530) 934-6500	(530) 934-6503	Paper Contact List
Great Basin Unified APCD	(760) 872-8211	(760) 872-6109	Paper Permits
Imperial County APCD	(760) 482-4606	(760) 353-9904	Fax Summary
Kern County APCD	(661) 862-5250	(661) 862-5251	Fax List
Lake County AQMD	(707) 263-7000	(707) 263-0421	Fax Summary
Lassen County APCD	(530) 251-8110	(530) 257-6515	No BUGs >300 kW
Mariposa County APCD	(209) 966-2220	(209) 742-5024	MS Excel
Mendocino County AQMD	(707) 463-4354	(707) 463-5707	MS Excel
Modoc County APCD	(530) 233-6419	(530) 233-5542	No BUGs >300 kW
Mojave Desert AQMD	(760) 245-1661	(760) 245-2699	MS Excel
Monterey Bay Unified APCD	(831) 647-9411	(831) 647-8501	Paper Permits and Lists
North Coast Unified AQMD	(707) 443-3093	(707) 443-3099	Fax Summary
Northern Sierra AQMD	(530) 274-9360	(530) 274-7546	No BUGs >300 kW
Northern Sonoma County APCD	(707) 433-5911	(707) 433-4823	No BUG Records
Placer County APCD	(530) 889-7130	(530) 889-7107	MS Excel
Sacramento Metro AQMD	(916) 874-4800	(916) 874-4899	MS Excel and Paper List
San Diego County APCD	(858) 650-4700	(858) 650-4659	MS Excel and Paper List
Santa Barbara County APCD	(805) 961-8800	(805) 961-8801	MS Excel
Shasta County AQMD	(530) 225-5674	(530) 225-5237	MS Excel
Siskiyou County APCD	(530) 841-4029	(530) 842-6690	No BUG Records
South Coast AQMD	(909) 396-2000	(909) 396-3340	On-Site Analysis of permit image files

Sources	Phone	Fax	Data Type
Air Districts			
Tehama County APCD	(530) 527-3717	(530) 527-0959	Fax Summary
Tuolumne County APCD	(209) 533-5693	(209) 533-5520	No BUG Records
Ventura County APCD	(805) 645-1400	(805) 645-1444	MS Access
Yolo-Solano AQMD	(530) 757-3650	(530) 757-3670	Paper Permits
Other Sources			
California Dept. of General Services-Office of Energy Assessments	(916) 323-8777		MS Excel
California Department of Corrections	(916) 327-1134		Fax Inventory Report
Pacific Gas & Electric	(415) 973-4212		MS Excel
Silicon Valley Power (City of Santa Clara)	(408) 615-2198	(408) 247-3730	MS Excel
Los Angeles Department of Water and Power	213-367-3772		MS Excel
Major Telecommunications Company	(562) 627-0186	(562) 627-0917	MS Excel

Table I-2. Other Organizations Contacted

Organization
Southern California Edison
San Diego Gas and Electric
California Independent System Operator
California Municipal Utilities Association
California Public Utilities Commission
Cummins West
Peterson Power
Hawthorne Power Systems
Association of Bay Area Governments
Portland General Electric

Appendix II - Methodology Used to Estimate the Potential Impact of BUG Use on Current Air District NO_x and PM Emissions

A discussion of a comparison of the NO_x and PM emissions associated with operating all of the diesel-fueled diesel engine BUGs for 4 hours / day in each of the state's air districts that supplied BUG inventory data to the district's current stationary source NO_x and PM emission inventory is given in Section 6. The methodology used to estimate each district's diesel BUG emissions is described below.

Section 3 noted that estimates of individual BUG NO_x and PM emission factors were included in the inventory database for those BUGs with known air permit application dates. These were BUGs with information supplied by the 13 air districts that included permit application dates in the information supplied to the project. For the collection of BUGs in those districts, each BUG's emission rate was calculated as follows:

$$\frac{Emission\ Rate}{(tons/hr)} = \frac{Load\ Factor * \frac{Engine\ Rating}{(hp)} * \frac{Emission\ Factor}{(g/bhp-hr)}}{908{,}000\,(g/ton)}$$

and the emission rates for all diesel BUGs in the district were summed to give the total emission rate for the simultaneous operation of all diesel BUGs in the district. The load factor was assumed to be 0.74 in keeping with the ARB recommendation in the OFFROAD model.

For diesel BUGs in air districts that did not provide permit application dates, the age distribution of diesel BUGs in the SCAQMD was assumed to apply. The SCAQMD age distribution was considered most representative because the SCAQMD accounts for nearly half the BUGs in the inventory. The SCAQMD age distribution for the two engine size ranges in Table 3 was applied to each of these other district's diesel BUG population to give an estimate of the number of diesel BUGs and cumulative capacity in each age and size range category.

Emission rates (ton / year) of all the diesel BUGs in the district in each age and size range were then calculated as follows:

$$\frac{Emission\ Rate}{(tons/hr)} = \frac{Load\ Factor * \frac{Cumulative\ Horsepower\ in\ Each\ Age\ and\ Size\ Range}{(hp)} * \frac{Emission\ Factor}{(g/bhp-hr)}}{908{,}000\,(g/ton)}$$

and the emission rates summed over all age and size ranges to give the total emission rate for the simultaneous operation of all diesel BUGs in the district. Again, a load factor of 0.74 was assumed.

Results of these emission rate calculations are summarized in Table II-1. In the table, the 13 districts with diesel BUG inventory capacity greater than 15 MW are listed individually. Population, capacity, and emission rates for the other 14 districts are combined together in another district total. The number of BUGs and total capacity (MW) for each district in Table II-1 are less than corresponding data in Table 4 because only clearly identified diesel-fueled diesel

BUGs are included in the Table II-1 data. The district's total emission rates serve as the basis for the daily mass emission estimates discussed in Section 7.

Table II-1. Emissions of NO_x and PM by District (tons/hr)

Air District	Number of Units	Total Capacity (MW)	Emissions (ton/hr)	
			NO_x	PM
South Coast	1,935	1,627	15.94	0.79
San Diego	480	317	3.17	0.15
Sacramento Metro	285	221	2.12	0.11
San Joaquin Valley Unified	296	210	2.10	0.10
Monterey Bay Unified	112	76	0.80	0.04
0Yolo/Solano	58	46	0.45	0.02
Ventura	46	40	0.40	0.02
Placer	26	34	0.34	0.02
Mojave Desert	59	33	0.33	0.02
Antelope Valley	32	18	0.18	0.01
San Luis Obispo	15	17	0.18	0.01
El Dorado	21	15	0.14	0.01
Feather River	23	15	0.15	0.01
Other Districts	86	60	0.64	0.03
Total	*3,474*	*2,729*	*26.8*	*1.3*